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Autistic features in school age children: IQ and gender effects in a population-based cohort

Hilde K. Ryland [a,b,*], Mari Hysing [b], Maj-Britt Posserud [b,c], Christopher Gillberg [e], Astri J. Lundervold [a,b,d]

[a] Department of Biological and Medical Psychology, University of Bergen, Postbox 7807, N-5020 Bergen, Norway
[b] Regional Centre for Child and Youth Mental Health and Child Welfare, Uni Health, Uni Research, Postbox 7800, N-5020 Bergen, Norway
[c] Department of Child and Adolescent Psychiatry, Haukeland University Hospital, N-5021 Bergen, Norway
[d] K. G. Jebsen Centre for Research on Neuropsychiatric Disorders, University of Bergen, Jonas Lies Vei 91, N-5009 Bergen, Norway
[e] Gillberg Neuropsychiatry Centre, Department of Neuroscience and Physiology, University of Gothenburg, Kungsgatan 12, SE-411 19 Gothenburg, Sweden

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ABSTRACT

Level and characteristics of intellectual function (IQ) have been associated with symptom presentation in children with autism spectrum disorder. The present study examined associations between IQ and autistic features in a sample of school aged boys and girls selected from a population-based cohort. The study included detailed examinations of 325 children aged 8–12 years, selected from the sample of the Bergen Child Study. IQ was assessed using the third version of the Wechsler Intelligence Scale for Children (WISC-III) and autistic features by parent reports on the Autism Spectrum Screening Questionnaire (ASSQ). Boys obtained higher ASSQ scores than girls. Gender and FSIQ had main effects on ASSQ scores, with the ASSQ scores showing a gradual decline with higher FSIQ for both genders. Discrepancies between verbal and performance IQ were relatively unrelated to ASSQ scores. The findings emphasize the importance of conducting careful assessments of children before reaching conclusions about cognitive function and autistic features.

1. Introduction

Intelligence and mental health are closely interrelated. A tested intelligence quotient (IQ) below 85 is known to increase the risk of mental health problems (Dekker & Koot, 2003; Dekker, Koot, van der Ende, & Verhulst, 2002), whereas higher IQ may serve to protect against the development of mental health problems in children (Ryland, Lundervold, Elgen, & Hysing, 2010). Autism spectrum disorder (ASD) is a neurodevelopmental disorder that may occur at all IQ-levels (American Psychiatric Association, 2013). Within the diagnostic category of ASD, there is a high male:female ratio (Fombonne, 1999, 2003). Interestingly, gender has been related to IQ in individuals with ASD, in that the male:female ratio has been reported to be largest in individuals with an IQ-level within the normal range (Gillberg, Cederlund, Lamberg, & Zeijlon, 2006) and approaching 1:1 in severely intellectually disabled subgroups (Wing, 1981). This illustrates the complexity of associations between IQ, gender and symptom load in neurodevelopmental disorders.

* Corresponding author at: Department of Biological and Medical Psychology, University of Bergen, Postbox 7807, N-5020 Bergen, Norway. Tel.: +47 99792312.
E-mail addresses: hilde.ryland@uni.no (H.K. Ryland), mari.hysing@psybp.uib.no (M. Hysing), maj-britt.posserud@uni.no (M.-B. Posserud), christopher.gillberg@gnc.gu.se (C. Gillberg), astri.lundervold@psybp.uib.no (A.J. Lundervold).

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Discrepancies between verbal and nonverbal IQ are frequently found in children (Kaufman & Lichtenberger, 2000) and have been related to autistic features. In a study of children and adults with Klinefelter syndrome (van Rijn & Swaab, 2011), those with discrepantly higher performance IQ (PIQ) (as measured by the WISC-III (Wechsler, 1991) or WAIS-III (Wechsler, 1997)) had higher levels of autistic traits – as measured with the *Autism Spectrum Quotient* (AQ) (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) – than individuals with discrepantly higher verbal IQ (VIQ). Discrepantly higher non-verbal abilities (as measured by the *Differential Ability Scale*) (Elliott, 1990) was also associated with significantly greater social impairment as assessed by the *Autism Diagnostic Observation Schedule* (ADOS) (Lord, Rutter, DiLavore, & Risi, 1999) in a group of 47 high-functioning children with autism aged 7–14 years (Joseph, Tager-Flusberg, & Lord, 2002). These results are, however, in conflict with results from a study by Black and colleagues (2009), showing that both discrepantly higher PIQ and VIQ (as measured by the WISC-III, WISC-IV (Wechsler, 2003), or WASI (Wechsler, 1999)) were associated with higher (i.e. more abnormal) social symptoms scores as assessed by the ADOS and the *Autism Diagnostic Interview* (ADI) (Le Couteur et al., 1989) in a sample of 78 high-functioning children with autism aged 6–17 years (Black, Wallace, Sokoloff, & Kenworthy, 2009). Finally, a study by Charman and collaborators (2011), including 156 children aged 10–14 years with ASD, could not support any relation between such a discrepancy score and symptom presentation of ASD.

Population-based studies show that autistic features are dimensionally distributed in the general population of children, and that boys show more autistic features than girls (Constantino & Todd, 2003; Kamio et al., 2012; Posserud, Lundervold, & Gillberg, 2006). Still, we do not know how IQ and gender are related to this broader distribution of autistic features. This lack of knowledge motivated the present study to examine associations between IQ and autistic features in a sample of children selected from the population-based Bergen Child Study cohort (BCS, www.uib.no/bib). Autistic features were assessed by parent reports on the Norwegian translation of the *Autism Spectrum Screening Questionnaire* (ASSQ) (Ehlers & Gillberg, 1993), which has been validated (Posserud, Lundervold, & Gillberg, 2009) and factor-analysed (Posserud et al., 2008) as part of the BCS. IQ was measured using the WISC-III (Wechsler, 1991). We examined how level and characteristics of IQ performance and gender were related to autistic features in this sample of children. We hypothesized that full scale IQ performance would be negatively associated with ASSQ scores, and that gender would influence the association between the two variables. The IQ performance was both analysed at a scale level and when categorized into three different levels that commonly are used clinically to describe the intellectual functioning of a child. Finally, we examined associations between a VIQ-PIQ discrepancy and the ASSQ scores.

2. Methods

2.1. Participants

Data from the first wave of the BCS, a longitudinal population-based study of mental health and development (www.uib.no/bib) were used. The first wave of the BCS had a three-phase design (for details, see Heiervang et al., 2007), and data included in the present study were collected as part of the third phase (see Lundervold, Posserud, Ullebo, Sorensen, & Gillberg, 2011; Posserud et al., 2013). In the first screening phase, a questionnaire, including the ASSQ, the *Strengths and Difficulties Questionnaire* (SDQ) plus a number of other scales/items, was sent to parents and teachers of all children attending the second to fourth primary school grades in all schools (public and private) in the municipalities of Bergen ($N = 9430$) and Sund ($N = 222$) in the autumn of 2002. Parents of 7007 children (74% of all the children in the population cohort) gave their informed consent to participate. A child was defined as screen positive if: (1) the SDQ total difficulties score exceeded the 90th percentile cut-off according to parents or teachers, (2) there was a severe impairment according to parents or teachers on the SDQ impact section, or (3) the score on one of the other scales included in the questionnaire, such as the ASSQ, exceeded the 98th percentile cut-off. The families of children defined as screen positives in the first phase and a random sample of screen negative children were invited to participate in the second phase of the BCS, with a participation rate of 44%. In this second phase, the parents were interviewed with the Development and Well-Being Assessment (DAWBA) (Goodman, Ford, Richards, Gatward, & Meltzer, 2000). The DAWBA is a structured interview with open-ended questions designed for interview or online self-completion, generating ICD-10 and DSM-IV psychiatric diagnoses in 5–17 year olds (www.dawba.com). In the BCS, the DAWBA was administered by trained interviewers and scored by two experienced and trained clinicians. When in doubt, cases were discussed between raters, and all diagnoses were finally reviewed and discussed with Professor R. Goodman, who has developed the interview. All children who obtained a diagnosis according to the DAWBA in the second phase, an equal number of screen positive and screen negative children randomly sampled from the second phase, and 25 children included directly from the first screening phase, were invited to participate in the extensive clinical examination of the third phase ($n = 421$). The final sample clinically examined included 329 children (78% of those invited). Parents had been interviewed (DAWBA) regarding 304 children in the previous (second) phase. The 25 children invited directly from the first screening phase had a chronic physical illness and were invited directly in order to increase the number of children with chronic illness in the sample. Table 1 provides a clinical description of the third phase sample. The BCS was approved by the Regional Committee for Medical and Health Research Ethics Western Norway, and by the Norwegian Data Inspectorate.

Table 1
Clinical characteristics of the third phase sample ($N = 329$).

	n
Screen positive phase 1	194
DAWBA diagnosis phase 2	97
K-SADS-PL diagnosis phase 3	142[a]
Major depressive disorder	2
Psychotic traits	1
Dysthymia	4
Depressive disorder INA	2
Adjustment disorder with depressive mood	1
Mania	1
Panic disorder	1
Separation disorder	4
Specific phobia	47
Social phobia	12
General anxiety disorder	5
Adjustment disorder with anxiety	3
Obsessive–compulsive disorder	6
Acute stress disorder	1
Enuresis	31
Encopresis	8
Attention Deficit Hyperactivity Disorder	52
Oppositional Defiant Disorder	24
Conduct Disorder	5
Tourette syndrome	10
Chronic tics	11
Transient tics	17
Alcohol abuse	1
Other psychiatric disorder	10
DISCO autism spectrum disorder phase 3	14
Neurological disorder	30

Note: DAWBA = Development and Well-Being Assessment. K-SADS-PL = Schedule for Affective Disorders and Schizophrenia for School-Age Children – Present and Lifetime Version. DISCO = Diagnostic Interview for Social and Communication Disorders.
[a] Note that children may have more than one diagnosis.

2.2. *Instruments*

2.2.1. *The Autism Spectrum Screening Questionnaire (ASSQ)*

The ASSQ includes a wide range of symptoms predictive of ASD, and is designed to be completed by teachers or parents. It consists of 27 items scored on a three-point scale: "not true" (0), "somewhat true" (1), or "certainly true" (2). Possible scores range from 0 to 54, with higher scores indicating greater symptom load. The ASSQ has been shown to have good screening properties both in clinical (Ehlers, Gillberg, & Wing, 1999; Guo et al., 2011; Mattila et al., 2012) and population-based samples (Mattila et al., 2012; Posserud et al., 2009). The BCS validation study showed that more than 90% of children who received an ASD diagnosis according to the Diagnostic Interview for Social and Communication Disorders (DISCO), were also rated above the 98th percentile on the ASSQ by parents and/or teachers, corresponding to a sensitivity of 0.91 and a specificity of 0.86 (Posserud et al., 2009). Previous studies from the BCS have shown that the ASSQ has good internal consistency (Cronbach's alpha = 0.86) (Posserud et al., 2006) and a stable three-factor structure with factors labelled Social difficulties (11 items), Motor/tics/OCD (7 items), and Autistic style (9 items) (Posserud et al., 2008). As described by Posserud et al. (2008), the autistic style factor includes items that characterize a verbal language and social-cognitive style often seen in high-functioning individuals with ASD. The English version of the ASSQ is available in the publications by Ehlers and Gillberg (1993) and Ehlers et al. (1999). In the present study, the sum scores of parent reports on the ASSQ were used as measures of autistic features.

2.2.2. *Wechsler Intelligence Scale for Children, 3rd ed. (WISC-III)*

The WISC-III is designed to assess intellectual abilities in children and adolescents aged 6–16 years. It contains 13 subtests, of which five are included in the verbal IQ (VIQ) score and another five in the performance IQ (PIQ) score. The full scale IQ (FSIQ) is a composite score based on the VIQ and PIQ scores. The WISC-III was administered according to the test manual and scored according to Swedish norms (Sonnander, Ramund, & Smedler, 1998) by well-trained and experienced test-technicians employed at a Neuropsychological Outpatient Clinic. The standard score of FISQ (Wechsler, 1991) was used as the measure of intellectual functioning in the present study.

The FSIQ score was analysed at a continuous as well as a categorical level, for which it was divided into three levels: FSIQ $<$70, FSIQ 70–84, and FSIQ $\geq$85 (including 21 children with FSIQ $\geq$115). A significant IQ discrepancy was defined as a difference between VIQ and PIQ of at least 14 IQ points, based on the IQ discrepancy that reaches statistical significance ($p < 0.05$) according to the Swedish WISC-III manual (Sonnander et al., 1998).

2.3. Missing data

When calculating the ASSQ total score, the mean score of the total sample was inserted for missing items when 4/27 (15%) or fewer items were missing. ASSQ forms with more than four items missing were discarded from the present analyses. Forms from 325 (98.8%) parents were completed with four or fewer items missing and included in the present study.

2.4. Statistical analyses

IBM SPSS Statistics 20 was used for data analyses. Independent-samples *t*-tests and chi-square tests were used to analyse gender-differences. Effect sizes (Cohen's d and ηp^2) of significant mean differences were calculated and interpreted according to Cohen (1988), in which a d value of 0.20 = small, 0.50 = medium, and 0.80 = large, and a ηp^2 of 0.01 = small, 0.06 = medium, 0.13 = large. Bivariate correlation analyses (Pearson's r) were used to analyse relations between IQ and ASSQ scores and interpreted according to Cohen (1988), in which an r value of 0.10–0.29 is low, 0.30–0.49 is moderate, and 0.50–1.0 is high. Significant results were followed by univariate ANOVAs using the GLM package, including the ASSQ scores as dependent variables in separate analyses and gender and the FSIQ score as fixed factors in a full factorial model. The analyses were repeated by including the three FSIQ levels as a fixed factor together with gender. Significant effects of the three FSIQ levels were followed by post hoc tests using Tukey HSD correction for multiple comparisons.

3. Results

3.1. Gender and age

The mean age of the sample was 10 years, with a four years range. There were significantly more boys (64.3%) than girls in the sample ($x^2 = 26.61$, $p < 0.001$), with a non-significant gender-difference in age (Table 2).

3.2. Intellectual function

Overall, the mean WISC-III scores were below the standardized mean of 100, with a wide distribution. Boys had significantly lower PIQ scores than girls ($t(323) = -3.05$, $p = 0.002$), while the mean difference for the other IQ scores were non-significant (Table 2).

Of the total sample, 42 children (15.8% of the boys and 7.8% of the girls) had FSIQ <70, 66 children (22.0% of the boys and 17.2% of the girls) between 70 and 84, and 217 children (62.2% of the boys and 75.0% of the girls) had FSIQ ≥85. There were 123 children (37.8%) showing a significant VIQ–PIQ discrepancy (68 boys and 55 girls), of which 39 children had discrepantly higher VIQ (VIQ > PIQ) (13.9% of the boys and 7.8% of the girls) and 85 children discrepantly higher PIQ (PIV > VIQ) (18.7% of the boys and 39.7% of the girls). The remaining 202 children had no significant VIQ–PIQ discrepancy (VIQ ~ PIQ).

3.3. Autistic features

The total ASSQ score in the sample ranged from 0 to 42, with a mean score of 6.4. Boys obtained significantly higher scores than girls on all ASSQ variables except the Autistic style factor score. The effect sizes of the significant mean differences between boys and girls ranged from small to medium size (Table 2). The mean ASSQ scores within the different FSIQ levels and discrepancy groups are shown for girls and boys in Table 3. The gender differences in ASSQ scores within the three FSIQ levels were all non-significant.

Table 2
Age, IQ and ASSQ scores (mean, SD and range) in the total sample and in boys and girls.

	Total ($N = 325$)	Boys ($n = 209$)	Girls ($n = 116$)	d
Age[a]	9.96 (0.97, 7.77–11.98)	10.02 (1.00, 7.77–11.98)	9.86 (0.92, 7.81–11.57)	
WISC-III IQ[a]				
FSIQ	89.12 (17.89, 37–133)	87.78 (18.20, 37–133)	91.54 (17.14, 37–126)	0.21
VIQ	88.58 (16.29, 42–136)	88.39 (17.24, 42–136)	88.91 (14.48, 42–116)	0.03
PIQ	92.30 (19.10, 32–136)	89.92 (18.42, 32–129)	96.59 (19.64, 35–136)**	0.35
ASSQ scores[a]				
Total score	6.42 (7.00, 0–42)	7.42 (7.46, 0–42)	4.61 (5.73, 0–31)***	0.42
Social difficulties	3.18 (4.05, 0–17)	3.79 (4.37, 0–17)	2.09 (3.14, 0–13)***	0.45
Motor/tics/OCD	0.76 (1.58, 0–12)	0.96 (1.72, 0–12)	0.41 (1.24,0–10)***	0.37
Autistic style	2.13 (2.23, 1–13)	2.30 (2.37, 0–13)	1.84 (1.92, 0–7)	0.21

Note: FSIQ = full scale IQ. VIQ = verbal IQ. PIQ = performance IQ. ASSQ = Autism Spectrum Screening Questionnaire. d = Cohen's d (effect size).
[a] Data generated from independent samples *t*-test and presented as mean (SD, range).
*** $p < 0.001$.
** $p < 0.01$.

Table 3
ASSQ scores in boys and girls according to FSIQ level and discrepancy score ($N = 325$).

	ASSQ total score[a]		Social difficulties factor score[a]		Motor/tics/OCD factor score[a]		Autistic style factor score[a]	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
FSIQ level								
<70	13.85 (9.16)	11.89 (8.13)	7.47 (5.28)	5.56 (3.97)	2.52 (2.27)	2.44 (1.59)	3.00 (2.80)	3.11 (2.37)
70–84	7.67 (5.46)	6.90 (4.99)	4.33 (3.76)	3.80 (3.85)	0.74 (1.20)	0.35 (0.75)	2.33 (2.14)	2.35 (1.90)
>85	5.69 (6.68)	3.33 (4.88)	2.69 (3.78)	1.34 (2.43)	0.64 (1.49)	0.21 (1.11)	2.11 (2.32)	1.59 (1.81)
Discrepancy score								
VIQ > PIQ	7.34 (6.44)	9.11 (12.38)	3.76 (4.05)	4.11 (5.64)	1.07 (1.67)	2.00 (3.46)	2.38 (2.13)	2.56 (3.00)
PIQ > VIQ	8.38 (8.74)	3.59 (4.17)**	4.33 (4.89)	1.63 (2.59)**	1.15 (1.76)	0.20 (0.54)**	2.23 (2.72)	1.41 (1.60)
VIQ ~ PIQ	7.16 (7.28)	4.72 (5.06)**	3.65 (4.30)	2.15 (2.97)**	0.88 (1.72)	0.33 (0.85)**	2.30 (2.33)	2.05 (1.91)

Note: FSIQ = full scale IQ. VIQ = verbal IQ. PIQ = performance IQ. ASSQ = Autism Spectrum Screening Questionnaire.
[a] Data generated from independent samples *t*-test and presented as mean (SD, range).
** $p < 0.01$.

3.4. Associations between intellectual function and autistic features

Table 4 shows the correlations between the FSIQ and ASSQ scores in the total sample and within the two gender groups. All correlations, except for the Autistic style factor score in boys, were statistically significant and in the low to medium range (Cohen, 1988).

Univariate ANOVA analyses showed a statistically significant main effect of gender and FSIQ score when the total ASSQ score, the Social difficulties and Motor/tics/OCD factor scores were included as dependent variables (Table 5). The effects were about medium size for gender and FSIQ on the full ASSQ score and the Social difficulties factor score, but the size was much smaller for gender on the Motor/tics/OCD factor score. The interaction effect was statistically significant ($p = 0.003$) for the Social difficulties factor score, meaning that this score was higher in boys than in girls (indicating more difficulties) in the lower end of the FSIQ scale, with a steeper slope in boys, making the Social difficulties factor score in the two gender groups

Table 4
Correlations between IQ and ASSQ scores in the total sample ($N = 325$).

	ASSQ total score	Social difficulties	Motor/tics/OCD	Autistic style
FSIQ total sample	−0.37**	−0.39**	−0.34**	−0.15**
FSIQ boys ($n = 209$)	−0.35**	−0.38**	−0.30**	−0.10
FSIQ girls ($n = 116$)	−0.40**	−0.37**	−0.43**	−0.23*

Note: FSIQ = full scale IQ. ASSQ = Autism Spectrum Screening Questionnaire.
** $p < 0.01$ (2-tailed).
* $p < 0.05$ (2-tailed).

Table 5
Summary of results from ANOVA, showing the effects of gender and FSIQ on ASSQ scores, with separate analyses for the FSIQ at a scale level and categorized into three levels ($N = 325$).

	FSIQ at a scale level			FSIQ categorized into three levels		
	F	*p*-Value	*d*	*F*	*p*-Value	ηp^2
ASSQ total score						
Gender	9.6	0.002	0.45	2.8	ns	0.01
FSIQ	2.6	<0.001	0.49	23.4	<0.001	0.13
Gender:FSIQ	1.4	0.059	0.23	0.3	ns	0.00
ASSQ Social difficulties						
Gender	12.5	<0.001	0.58	4.6	0.033	0.014
FSIQ	2.8	<0.001	0.52	22.5	<0.001	0.12
Gender:FSIQ	1.8	0.3	0.28	0.41	ns	0.00
ASSQ Motor/tics/OCD						
Gender	5.5	0.020	0.03	1.7	ns	0.01
FSIQ	2.4	<0.001	0.47	25.7	<0.001	0.14
Gender:FSIQ	0.72	ns	0.13	0.2	ns	0.00
ASSQ Autistic style						
Gender	1.4	ns	0.01	0.1	ns	0.00
FSIQ	1.1	ns	0.29	4.3	0.001	0.026
Gender:FSIQ	0.9	ns	0.17	0.5	ns	0.00

Note: FSIQ = full scale IQ. ASSQ = Autism Spectrum Screening Questionnaire. *d* = Cohen's *d* (effect size). $\eta p^2 = \eta^2$ (effect size). ns = non-significant.

similar at the highest end of the FSIQ scale. A more parallel slope, with boys obtaining the highest ASSQ scores, was found on the other two scales. The effects of gender and FSIQ were non-significant for the Autistic style factor score.

The ANOVA analyses were repeated by substituting the continuous FSIQ score with three levels of FSIQ that commonly are used clinically to evaluate a child's intellectual function. The effect of FSIQ-level was statistically significant for the ASSQ total score and all the three factor scores, with large ηp^2 for all but the Autistic style factor score (Table 5). A post hoc analysis with Tukey correction for multiple comparisons showed that the ASSQ total and all the factor scores in the IQ <70 subgroup were significantly higher than in the other two groups ($p < 0.001$). Furthermore, the intermediate group was higher than the IQ ≥ 85 group on the ASSQ total ($p = 0.008$) and the Social difficulties factor score ($p < 0.001$). The effect of gender was only statistically significant for the Social difficulties factor score, reflecting that boys obtained a somewhat higher score than girls across the three FSIQ levels (Table 3). None of the interactions between FSIQ and gender were statistically significant.

3.5. IQ discrepancy score and autistic features

The effect of discrepancy group on the ASSQ scores was investigated by ANOVA analyses including discrepancy score (VIQ > PIQ, PIV > VIQ, VIQ ~ PIQ) as a factor in separate analyses together with gender and an interaction term. A statistically significant effect of discrepancy group was only found on the Motor/tics/OCD factor, $F = 4.3$, $p = 0.14$, $\eta p^2 = 0.026$. On this variable, there was also a significant interaction effect between discrepancy group and gender, $F = 3.9$, $p = 0.22$, $\eta p^2 = 0.024$, reflecting that girls had a higher score than boys in the subgroup with VIQ > PIQ. Boys, on the other hand, showed a significantly higher score when the PIQ > VIQ (Table 3). The effects were non-significant for all ASSQ scores when FSIQ level or the continuous FSIQ score were included as covariates, and when splitting the discrepancy group into those with and without a discrepancy.

4. Discussion

4.1. Summary of findings

The present study examined associations between IQ, gender and autistic features in a sample of children selected from a population-based cohort. First of all, we did not find the expected impact of having a large discrepancy between verbal and performance IQ on the frequency of autistic features. The only effect found was on the Motor/tics/OCD factor score. The relationship between IQ and autistic features was negative and moderate for all ASSQ variables except the Autistic style factor score, with the ASSQ score showing a gradual decline with higher FSIQ for both genders. The continuous FSIQ score interacted with gender on the Social difficulties factor score.

4.2. General discussion

In line with findings from population studies (Constantino & Todd, 2003; Kamio et al., 2012; Posserud et al., 2006), parents rated the ASSQ scores significantly higher in boys than in girls. Surprisingly, this was not found for the Autistic style factor score. According to Posserud et al. (2008, p. 109), "this factor could represent a set of items that are more specific for children with ASD as opposed to children with social difficulties for other reasons". Also, in clinical samples of children with ASD, the frequency of boys and girls presenting with these features have not been shown to differ significantly, whereas they discriminated well between ASD and non-ASD cases and between ASD and ADHD cases (Kopp & Gillberg, 2011). In a sample selected from a population, then, one should perhaps not expect these more "ASD specific" features to occur more or less frequently in any of the two genders. This assumption was confirmed by a follow-up analysis where the ASSQ scores were *z*-transformed, showing that the Autistic style factor score was the least widespread for both genders.

Overall, discrepant verbal versus non-verbal skills were not associated with a specific pattern of ASD symptoms in the present study. In this respect, our results supported the conclusion by Charman et al. (2011). Conflicting results with other studies may be related to differences in assessment methods (ASSQ versus AQ/ADOS/ADI) and sample characteristics (children selected from a population-based sample versus clinical samples). Also, one longitudinal study of ASD has demonstrated that negative effects of "non-verbal learning problems" (VIQ > PIQ) on social and executive outcome were demonstrated only for the subgroup with persistent (more than nine years after study in school age) non-verbal learning problems (Hagberg, Nyden, Cederlund, & Gillberg, 2013). However, the effects shown in the present study of discrepancy group and its interaction with gender on the Motor/tics/OCD factor are worth a comment. On this factor score, the impact of a discrepantly higher VIQ or PIQ was specific to girls and boys, respectively. The finding of a higher ASSQ score in boys with PIQ > VIQ accords with associations found between discrepantly higher nonverbal abilities and autistic features in samples of predominantly boys with ASD (Black et al., 2009; Joseph et al., 2002) and Klinefelter syndrome (van Rijn & Swaab, 2011). The finding of a higher Motor/tics/OCD factor score in girls with VIQ > PIQ is not as easily understood, as girls are scarce in the studies examining these associations (Black et al., 2009; Charman et al., 2011; Joseph et al., 2002; van Rijn & Swaab, 2011). Better verbal versus performance scores in children with ASD has been linked to poor coordination, but not specifically in girls (Wing, 1981). Future studies should further investigate this gender difference in IQ discrepancy and autistic features.

The present study included information about intellectual functioning as measured by the full-scale score on an IQ test and by categorizing the scores according to a tradition commonly used in the clinic to describe intellectual function of a child.

Based on the analyses of the full scale, the difference between girls and boys was clearly larger when the FSIQ score was low, with similar results between the two gender groups when they obtained a high FSIQ score together with a score of or about zero on the ASSQ. The main contribution of including levels was to show that although ASD may occur at all levels of intellectual functioning (American Psychiatric Association, 2013), an IQ level <70 is not only associated with a high rate of ASD (DiGuiseppi et al., 2010; Gillberg & Soderstrom, 2003; Kent, Evans, Paul, & Sharp, 1999), but also with autistic features in a sample where these features are widely distributed along the whole scale. Our findings are in accordance with studies showing high rates of social problems in children with intellectual disability (Dekker et al., 2002), as well as with results from a large-scale Japanese population survey (Kamio et al., 2012), in which the authors reported that scores on the *Social Responsiveness Scale* (SRS), a questionnaire of autistic traits (Constantino & Gruber, 2005), showed low correlation with an IQ score in the normal range, while children with intellectual disability tended to have higher SRS scores. IQ was also found to be a moderator of ASD symptoms in a study of adults with intellectual disability when split into ''low IQ'' versus ''high IQ'', showing a decrease in ASD symptoms with higher IQ (Matson, Dempsey, Lovullo, & Wilkins, 2008). In contrast, intellectual development was not found to be a moderator of ASD symptoms in a recent study of infants and toddlers with autism, PDD-NOS, and atypical development when split into a ''low developmental level'' and a ''high developmental level''. However, developmental level was found to be higher in individuals who displayed less ASD symptoms (Matson et al., 2013).

The high ASSQ scores at the lower end of the IQ scale may be related to the fact that the children with a FSIQ <70 were characterized by a rather high rate of neurological disorders (26.2%, compared to 9.1% in children with FSIQ 70–84, and 3.2% in children with a >85) in addition to their intellectual disability. Neurological disorders have commonly been associated with symptoms of ASD (Gillberg, 2010; Ryland, Hysing, Posserud, Gillberg, & Lundervold, 2012), and it has been proposed that cognitive impairments, such as intellectual disability, in children with neurological disorders may inhibit their social information processing skills, which, in turn, may have a negative impact on the children's social functioning (Boni, Brown, Davis, Hsu, & Hopkins, 2001; Bottcher, 2010); e.g., reflected in more autistic features.

4.3. Strengths and limitations

The main strength of the study was the use of a standardized test of intellectual function (WISC-III) and a validated instrument for autistic features (ASSQ). Other strengths are related to characteristics of the sample. Although ''enriched'' by both developmentally and physically disabled children, the children were selected from a population-based study. Because of this, the sample included both children with and without problems according to a screening instrument assessing mental health, and the children showed a wide distribution of both intellectual function and autistic features. The study also included a substantial number of girls, making it possible to examine gender-differences in WISC-III and ASSQ scores and relations between the two.

The present study has several limitations. First of all, autistic features were not assessed by including direct observation and standardized clinical evaluation of the children, but the information was solely based on parent reports. Secondly, the distribution of FSIQ scores was skewed towards the lower end of the FSIQ-scale, probably due to how the sample was recruited. On the other hand, covering the full range of FSIQ scores may also be considered to be a strength. Thirdly, since the ASSQ factors have not been validated, the results regarding factor scores should be interpreted with caution. Furthermore, methodological differences regarding sample and assessment made it difficult to compare the present findings with results of earlier studies, which have mainly focused on children with ASD. However, little was known about how intellectual function and gender is related to the broader distribution of autistic features in children. As such, we believe the present study has added new knowledge, although firm conclusions regarding the generalizability of the results await further studies including larger samples and subgroups of children representing the different FSIQ levels and FSIQ discrepancies. Finally, cognitive abilities have recently been associated with adaptive functioning in preschool children (Hedvall et al., 2013) and young adults (Hagberg et al., 2013) with ASD. Future studies should include measures of adaptive functioning to further assess the impact of cognitive function on outcome in children with autistic features.

4.4. Clinical implications

In the present sample selected from a population-based cohort, the relationship between measures of intellectual functioning and autistic features was far from straightforward. This highlights the importance of not inferring intellectual function from autistic features and vice versa when investigating children from a general population, and the importance of conducting a careful assessment before reaching clinical conclusions in a given child.

5. Conclusion

The present study showed that the relationship between autistic features as assessed by the ASSQ and results on a commonly used IQ-test was mainly explained by children with FSIQ scores at the lower end of the distribution. Discrepancies between verbal and performance IQ were found to be relatively unrelated to ASSQ scores. The present findings call for future studies including a broader range of cognitive tasks and measures of adaptive functioning, and emphasize the importance of broad and careful assessments of children before reaching conclusions about cognitive function and autistic features.

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